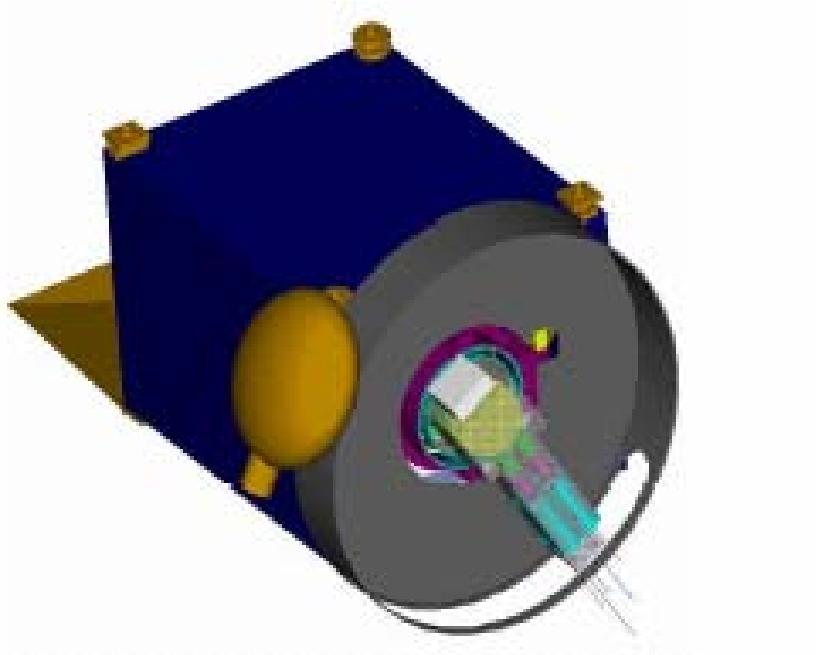
NPOESS Aerosol Polarimetry Sensor (APS): Overview & Status

2003 International Geoscience
And Remote Sensing Symposium
Toulouse, France
July 21-25, 2003

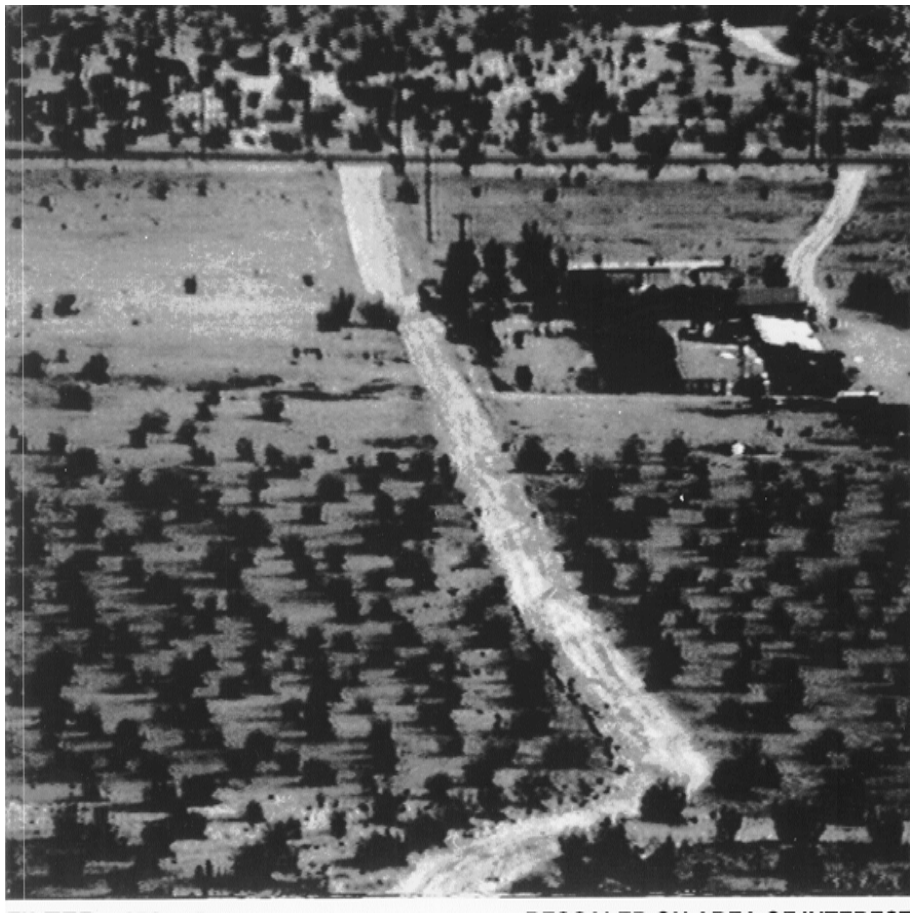
Dr. Vincent Grano, IPO
Dr. Shiva Ubhayakar, NGST
Mr. John M. Haas, Aerospace Corp.
Dr. Carl Schueler, SBRS



Agenda

- APS Requirements
- Acquisition and Design Approach
- Sensor & Environmental Data Record (EDR) Overview
- Status
- Role of Science Community

The APS Sensor



- Retrieves specified aerosol and cloud parameters
- Sensor for satisfying Four Environmental Data Records (EDRs)
- Uses multi-angular multispectral photopolarimetry
- Provides accurate and stable climate EDRs
- Prime contractor: Northrop Grumman Space Technology, Redondo Beach, California
- Prime Subcontractor: Raytheon Santa Barbara Remote Sensing (SBRS), Goleta, California

APS Mission Requirements

- Provide data to satisfy need to determine aerosol climate forcing
- Provide data to measure global aerosol variability
- Provide data to fill operational products

"The primary mission of the APS is to provide high quality radiometric data as a function of polarization in the visible through short-wave infrared (SWIR) spectral regions in support of climate studies. In addition, the APS shall support worldwide DoD and civilian operations by augmenting and enhancing applicable Visible & Infrared Imaging Radiometer Suite (VIIRS) EDRs "

APS EDRs

- Aerosol Optical Thickness
  - Increased accuracy over land and over water
- Aerosol Particle Size
  - Effective radius and effective variance for each mode (fine and coarse)
  - Increased accuracy over land and water
- Aerosol Refractive Index, Aerosol Single-scattering Albedo and Aerosol Shape (Sphericity)
- Cloud Particle Size, Variance and Distribution
  - Effective radius and effective variance

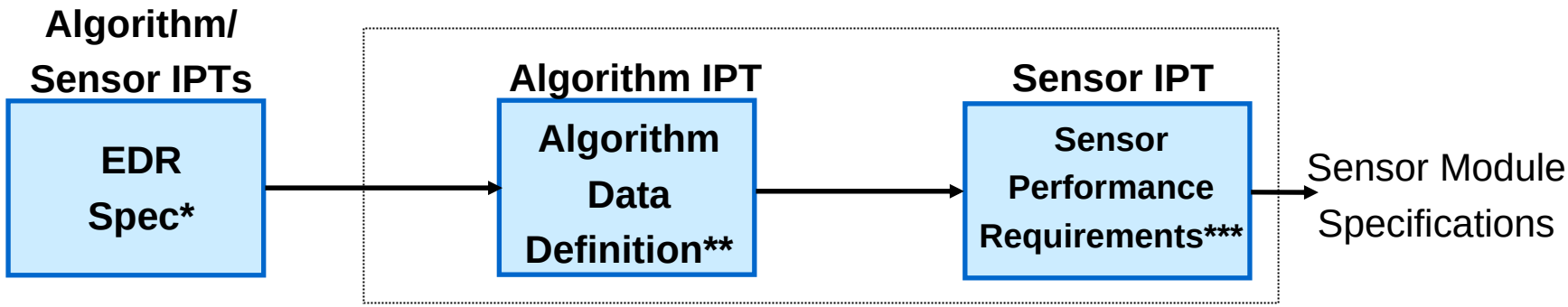
NPOESS
Design Approach for APS

- The APS EDRs are the ultimate deliverables to the user community
  - For each EDR, a set of attributes was developed by the user community; some attributes may have a minimum performance level (Threshold) and a goal performance level (Objective)

- Design optimized to
  - Meet EDRs with better than threshold performance
  - Accommodate the Government's priorities
  - Meet costs and schedule with minimum risk

- Performance specifications (systems, sensor, algorithm, and interfaces) developed with guaranteed levels of performance for final acceptance and validation

EDR Attributes Flowed Down to Sensor Performance Requirements



- **Horizontal Cell Size**
- **Horizontal / Vertical Coverage**
- **Measurement Range**
- **Measurement Accuracy & Precision**
- **Long-term Stability**
- **Mapping Uncertainty**

- **Auxiliary/Ancillary Data**
- **Bands CW/BW**
- **Dynamic Range/Sensitivity**
- **Radiometric Accuracy/Stability**
- **Horizontal Sampling Interval (HSI)**
- **Spatial resolution (GIFOV)**
- **Polarization Accuracy & Precision**

- **Scan definition**
- **Calibration Definition**
- **IFOV/Response Uniformity**
- **Crosstalk**
- **Stray Light Rejection**
- **LOS Pointing/Jitter Requirements**
- **CW/BW Tolerance**
- **Band co-registration**
- **Spectral Uniformity**

*APS System Specification

** Algorithm Data Definition (ADD) Documents (Y0012603—Y0012607)

*** Sensor Requirements Allocation Document (RAD)

Major Design Drivers

- **The APS shall meet specified EDR performance**
- **Provide high quality radiometric data as a function of polarization in the visible through short-wave infrared (SWIR) spectral regions in support of climate studies**
- **Horizontal Cell Size (nadir); Threshold: 10 km; Objective 1 km**
- **Long-term Stability; e.g., AOT Threshold 0.01; Objective 0.005**
- **Measurement Range; e.g., AOT Threshold 0-5 ; Objective 0-10**

APS Integrated Requirements Priority List

1. Aerosol EDRs Quality
2. Cloud EDRs (Cloud Particle Size Distribution) Quality
3. Cost
4. VIIRS* Synergy
5. Schedule
6. Data Rate
7. Volume
8. Power
9. Mass
10. Pre-planned Product Improvements

* Visible and Infra-red Imager Radiometer Suite

APS Measurements

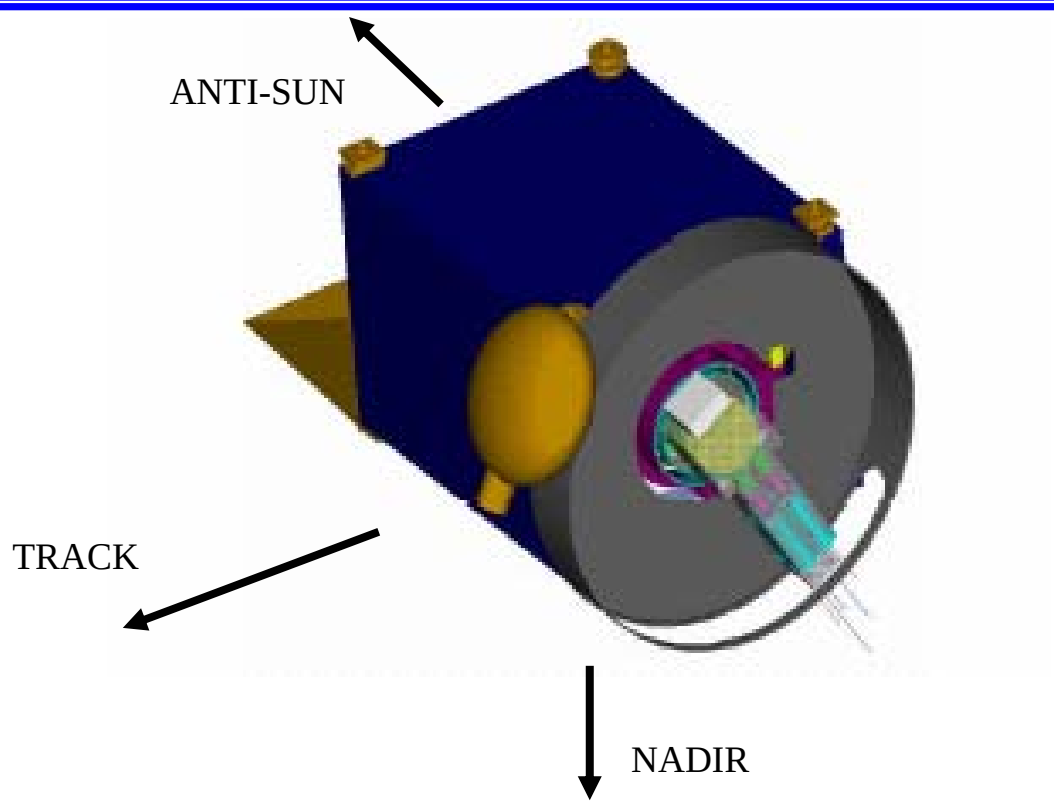
- **Nine spectral bands 400 to 2400 nm**
  - **412, 488, 555, 672, 865, 910/940*, 1378, 1610, and 2250 nm**
  - **Most are the same as VIIRS for synergy**
- **One band will be replaced to measure water vapor**
- **Nadir looking**
  - **10 km swath**
- **Multi-angular along-track**
  - **± 60 degrees about nadir in the along-track direction**
- **Mid-morning orbit**
  - **2130 LTAN orbit or 0930 LTDN**
- **Polarization**
  - **0, 45, 90, and 135 degrees**

* 910 or 940, based on sensor risk assessment

APS Radiometric Performance

Requirement	Performance
Radiometric Sensitivity: 540 @ L Typical	800 @ L Typical
Polarimetric Accuracy: 0.2%	< 0.15% Typical
Calibration: Radiometric: 5% accuracy	3% with VIIRS
Polarimetric Precision: < 0.13%	<0.087% Typical
Scan: Up to +/ - 60 deg about nadir along track	Up to +/ -60 deg 60 deg about nadir along track

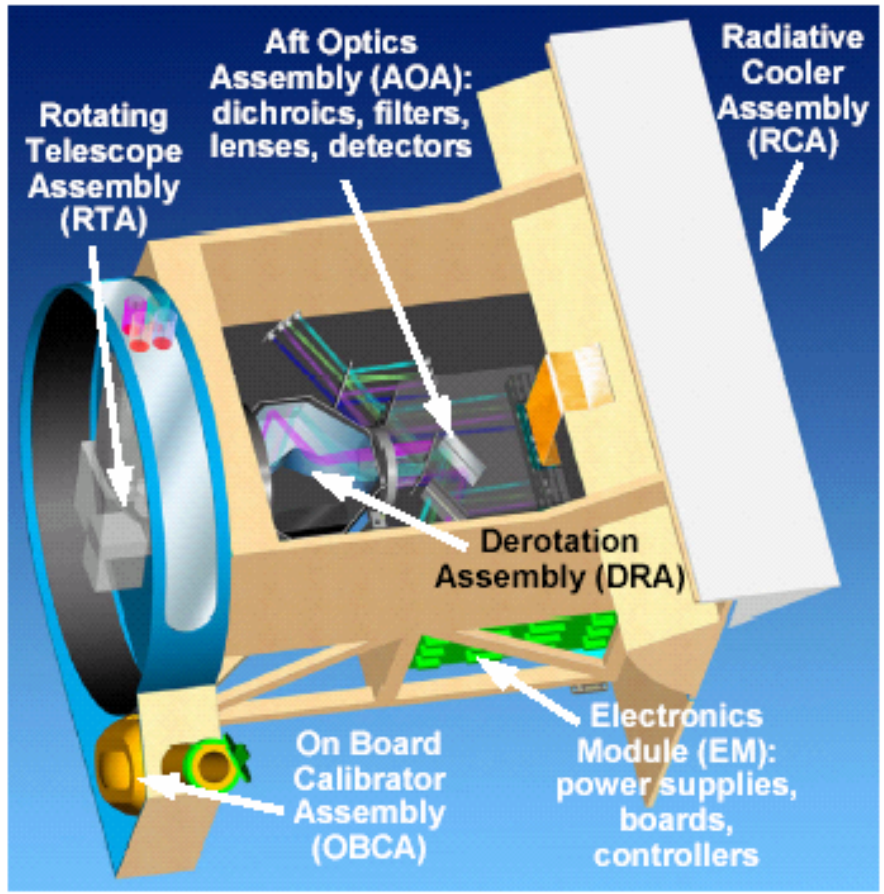
PRE-PDR APS Sensor Design



MASS: 33.5 kg.
DATA RATE: 88 kbp/s average, 210 kbp/s peak
POWER: 37.5 W Peak
SIZE: 66 (Track) x 52 (Anti-Sun) x 41 (nadir) cm

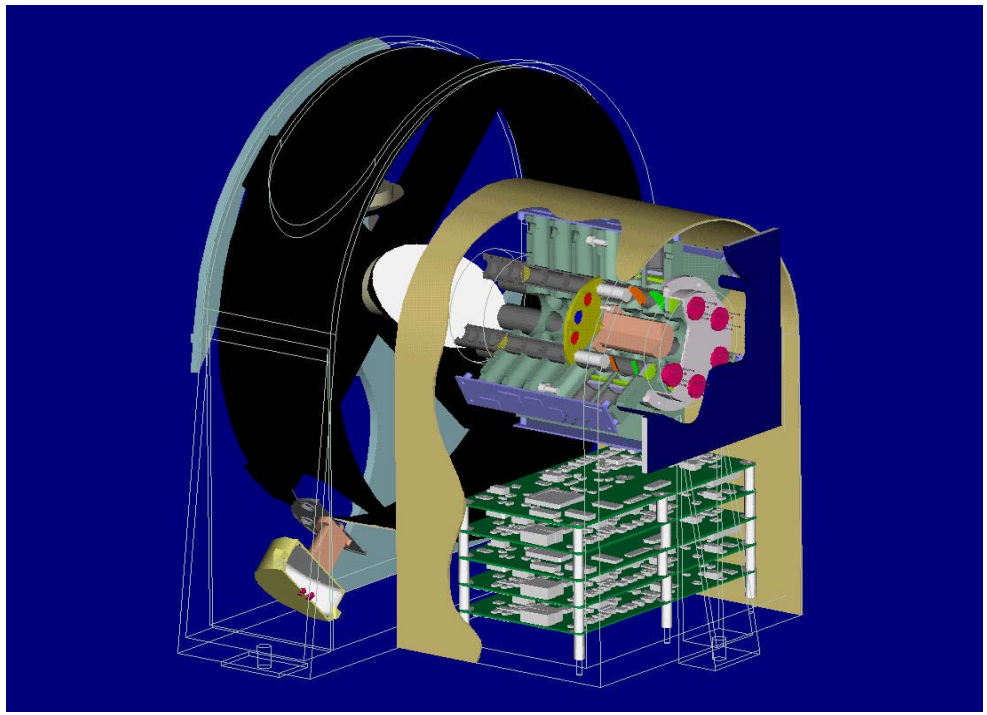
APS Rotating Telescope Assembly Subsystems

- **Eliminates Reflecting Surfaces Before Polarization Analyzers**
- **Conjugate Telescopes for Orthogonal Polarization Components**
- **Heritage Electro-Mechanical Interfaces and Implementation of**



APS Scanning Mirror Assembly Subsystems

- **EOSP Heritage Crossed Scan Mirrors**
- **Conjugate Telescopes for Orthogonal Polarization Components**
- **Simple Heritage Design**



SELECTED EDR ACCURACY and STABILITY REQUIREMENTS

EDR ACCURACY	Threshold	Objective	Spec.
AOT (Ocean)	0.02 or 7%	0.01 or 5%	0.01 or 5%
AOT (Land)	0.04 or 10%	0.03 or 7%	0.03 or 7%
Aerosol Effective Radius	0.1 or 10%	0.05 or 5%	0.05 or 5%
Aerosol Effective Variance	0.3 or 50%	0.2 or 30%	0.2 or 30%
Refractive Index	0.02	0.01	0.015
Single Scatter Albedo	0.03	0.01	0.02
Cloud Effective Radius	1.0 or 10%	0.5 or 5%	0.75 or 7. 5%
Cloud Effective Variance	0.05 or 50%	0.04 or 40%	0.05 or 50%

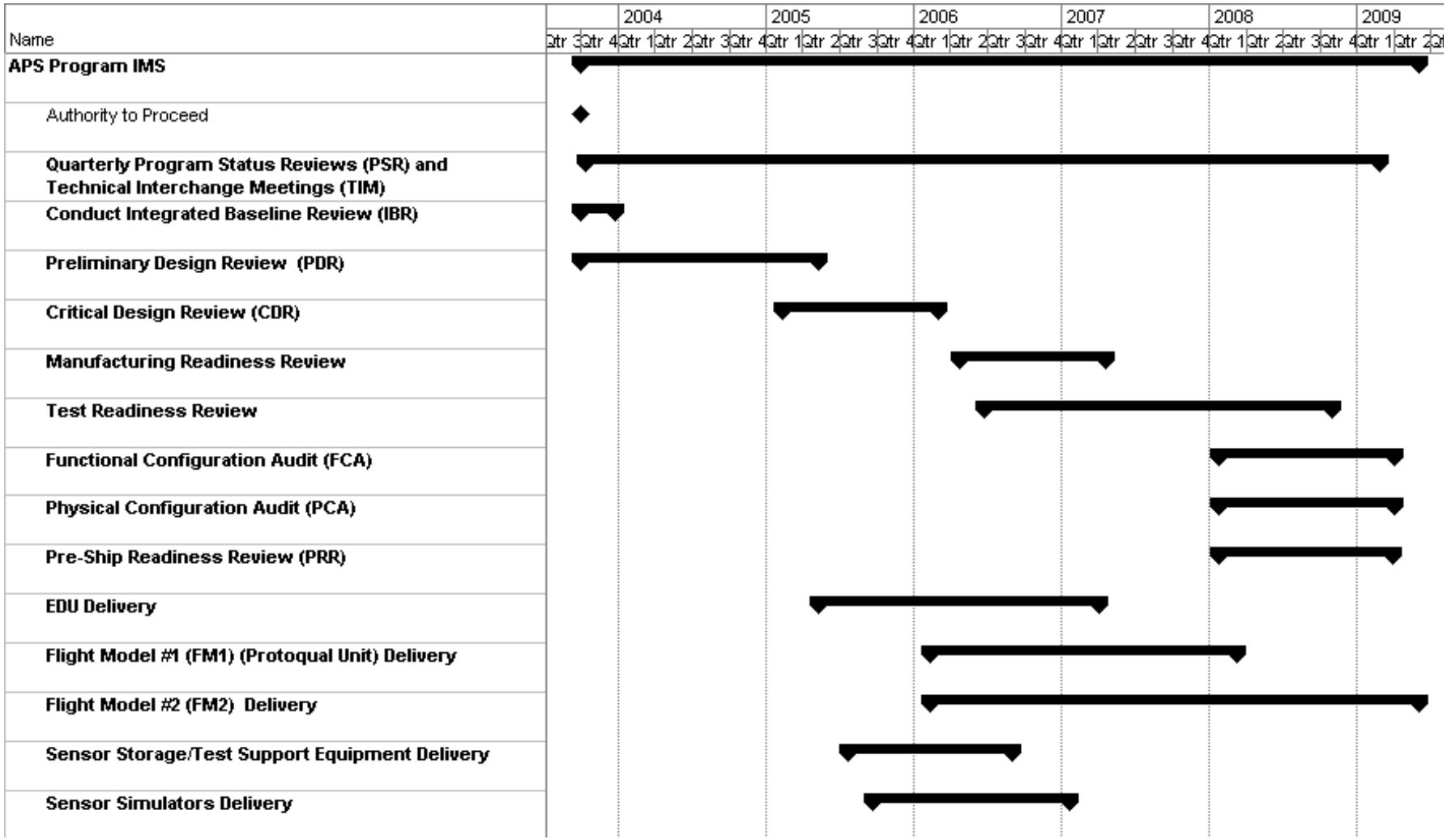
EDR STABILITY	Threshold	Objective	Spec.
AOT (Ocean)	0.01	0.005	0.005 05 2.5%
AOT (Land)	0.01	0.005	0.005 or 2.5%
Aerosol Effective Radius	0.05 or 10%	0.05 or 5%	0.05 or 5%
Aerosol Effective Var.	0.2 or 40%	0.1 or 20%	0.1 or 20%
Refractive Index	0.01	0.005	0.0075
Single Scatter Albedo	0.02	0.01	0.01
Cloud Effective Radius	0.5 or 5%	0.3 or 3%	0.4 or 4%
Cloud Effective Variance	0.04 or 40%	0.03 or 30%	0.04 or 40%

SELECTED EDR PRECISION REQUIREMENTS

EDR PRECISION	Threshold	Objective	Spec.
AOT (Ocean)	0.01	0.005	0.01 or 2%
AOT (Land)	0.03	0.02	0.02 or 2.5%
Aerosol Effective Radius	0.05 or 10%	0.05 or 5%	0.05 or 10% *
Aerosol Effective Variance	0.1 or 40%	0.1 or 20%	0.1 or 40% *
Refractive Index	0.01	0.005	0.01 **
Albedo	0.02	0.01	0.02 ***
Cloud Effective Radius	0.5 or 5%	0.3 or 3%	0.4 or 4%
Cloud Effective Variance	0.04 or 40%	0.03 or 30%	0.04 or 40%

* AOT < 0.8, ** AOT < 1.3, *** AOT < 1.5

APS Schedule



Science Interactivity Approach

- Users and scientists involved throughout program
  - Definition of original requirements
  - Continuing role of APS Operational Algorithm Team
  - Will participate in Calibration/Validation
- Participants in sensor/system procurement process
  - Attend and provide technical assessment of contractor performance
- Input and peer review for algorithm upgrades
- APS Algorithm Theoretical Basis Documents will be available by April 04

Some Final Thoughts

- Making the transition from research to operations
- Science-quality data at operational refresh rates
- Science and research applications largely unexplored
- Capabilities in combination with VIIRS